

Thermal pre-ignition agents

The present invention provides pre-ignition agents which can be used, for example, as thermal fuses in gas generators for motor vehicle safety systems.

- 5 Thermal pre-ignition agents are pyrotechnic substances or mixtures. They have the function, *inter alia*, of igniting the gas-producing mixtures of the gas generator, which generally have very high thermal stability, in a controlled manner in the event of a vehicle fire.
- 10 There are used as thermal pre-ignition agents, for example, nitrocellulose, propellant-charge powders derived therefrom, or the mixtures based on nitrotriazolone and guanidine nitrate described in patent application DE 197 30 873 A1. These mixtures have
- 15 ignition temperatures of approximately 160°C and, in the case of nitrocellulose, have only inadequate long-term stability.

The object of the present invention was to provide pyrotechnic mixtures having ignition temperatures of

20 about 200°C and adequate long-term stability, which mixtures can be used as thermal pre-ignition agents for gas generators in motor vehicle safety systems. The object underlying the invention has been achieved by the use of 2-[bis-(2,4,6-trinitrophenyl)]aminoethyl nitrate,

25 abbreviated to dipicrylaminoethyl nitrate (DPN). This substance can be used either on its own or in mixtures with further components. DPN can be prepared from 2,4-dinitrochlorobenzene and ethanolamine with subsequent nitration (lit.: R.V. Clark, Ind. Eng. Chem., 25, 1385

30 (1933)). The structural formula is as follows:

There can be used as additives:

15 nitroguanidine, nitroaminoguanidine, nitrotriazolone,
derivatives of tetrazole, such as 5-aminotetrazole,
ditetrazolylamine, ditetrazole and salts thereof,
nitraminotetrazole and its salts, such as ammonium
nitraminotetrazole and aminoguanidinium nitramino-
20 tetrazole, aminoguanidine nitrate, diaminoguanidine
nitrate, triaminoguanidine nitrate, guanidine nitrate,
dicyandiamidine nitrate, diaminoguanidine
azotetrazolate.

25 nitrates of the alkali or alkaline earth metals or of ammonium such as sodium nitrate or potassium nitrate,

perchlorates of the alkali or alkaline earth metals or of ammonium, peroxides of the alkaline earth metals or of zinc.

3. Reducing agents (on their own or in mixtures)

5 aluminium, titanium, titanium hydride, boron, boron hydride, zirconium, zirconium hydride, silicon, graphite, activated carbon, carbon black.

4. Binders (on their own or in mixtures)

10 cellulose and derivatives thereof, polyvinylbutyrals, polynitropolyphenylene, polynitrophenyl ether, Plexigum, polyvinyl acetate and copolymers.

5. High-energy additives (on their own or in mixtures)

hexogen, octogen and nitrocellulose.

6. Combustion moderators and processing aids (on their own or in mixtures)

15 ferrocene and derivatives, acetonylacetates, salicylates, silicates, silica gels, boron nitride.

20 Production and processing are carried out according to known and conventional processes. These include, for example, kneading, extrusion, extrusion moulding, pelleting or granulation.

The Examples which follow are intended to illustrate the invention in greater detail without limiting it.

25 Table 1 shows the compositions of twelve different mixtures. The components were weighed in the indicated weight ratios (amounts are in percent by weight (wt.%) into plastics beakers and homogenised for 30 minutes in a tumbler mixer.

Table 1: Examples

| Mixture | DPN in wt. % | Nitroguanidine in wt. % | 5-Amino- tetrazole in wt. % | Guanidine nitrate in wt. % | Potassium nitrate in wt. % | Sodium nitrate in wt. % | Potassium perchlorate in wt. % |
|---------|-----------------|----------------------------|-----------------------------------|----------------------------------|----------------------------------|-------------------------------|--------------------------------------|
| 1 | 50 | | | | 50 | | |
| 2 | 50 | | | | | 50 | |
| 3 | 50 | | | | | | 50 |
| 4 | 20 | 30 | | | 50 | | |
| 5 | 20 | 30 | | | | 50 | |
| 6 | 20 | 30 | | | | | 50 |
| 7 | 20 | | 30 | | 50 | | |
| 8 | 20 | | 30 | | | 50 | |
| 9 | 20 | | 30 | | | | 50 |
| 10 | 20 | | | 30 | 50 | | |
| 11 | 20 | | | 30 | | 50 | |
| 12 | 20 | | | 30 | | | 50 |

Table 2 shows the heat of explosion of the mixtures and their friction and impact sensitivity. The friction and impact sensitivity was measured according to methods of the Bundesanstalt für Materialforschung [Federal Institute of Materials Research] (BAM), while the heat of explosion was measured using a calorimeter from EKA.

Table 2: Overview of the heat of explosion and friction and impact sensitivity

| Mixture | Heat of explosion in J/g | Friction sensitivity in N | Impact sensitivity in J |
|---------|--------------------------------|---------------------------------|-------------------------------|
| 1 | 4859 | 240 | 6 |
| 2 | 3280 | 240 | 7.5 |
| 3 | 5915 | 120 | 5 |
| 4 | 5157 | 360 | 7.5 |
| 5 | 3125 | 120 | >30 |
| 6 | 5523 | 80 | 10 |
| 7 | 4014 | 240 | 6 |
| 8 | 3187 | 360 | 15 |
| 9 | 5056 | 80 | 6 |
| 10 | 4509 | 360 | 7.5 |
| 11 | 3484 | 360 | 10 |
| 12 | 5115 | 160 | 10 |

Table 3 summarises the deflagration points before and after exposure to heat (400 h, 110°C) and the weight losses after exposure to heat for 72 hours and 400 hours at 110°C. The deflagration points were determined by thermogravimetric analysis (Mettler) at a rate of heating of 10°C per minute. The weight loss was measured analogously to the Holland test.

After 400 hours, only slight weight losses of from 0.2 to 0.5 wt.% are found, and there is no significant change in the deflagration temperature after exposure to heat.

Table 3: Overview of weight losses and deflagration temperatures

| Mixture | Weight loss 72 h 110°C in wt. % | Weight loss 400 h 110°C in wt. % | Deflagration temperature in °C | Deflagration temperature after 400 h, 110°C in °C |
|---------|--|---|--------------------------------------|--|
| 1 | 0.11 | 0.27 | 203 | 202 |
| 2 | 0.15 | 0.35 | 203 | 203 |
| 3 | 0.12 | 0.29 | 201 | 201 |
| 4 | 0.11 | 0.49 | 207 | 206 |
| 5 | 0.16 | 0.53 | 196 | 194 |
| 6 | 0.11 | 0.49 | 201 | 202 |
| 7 | 0.10 | 0.44 | 196 | 200 |
| 8 | 0.11 | 0.42 | 178 | 184 |
| 9 | 0.11 | 0.42 | 196 | 198 |
| 10 | 0.09 | 0.18 | 205 | 205 |
| 11 | 0.12 | 0.26 | 206 | 208 |
| 12 | 0.11 | 0.31 | 205 | 205 |

The Examples show that the mixtures defined according to the invention have deflagration temperatures in the range from 178 to 208°C and are to be regarded as stable according to the requirements of the automotive industry.

The present invention specifically provides:

Thermal pre-ignition agents which contain as a component dipicrylaminoethyl nitrate (DPN) in amounts by weight of from 10 to 100 %.

Thermal pre-ignition agents which, in addition to DPN, contain nitrogen-containing compounds, on their own or in mixtures, in amounts by weight of from 0 to 90 %, such as, for example, nitroguanidine, nitroaminoguanidine, 5 nitrotriazolone, derivatives of tetrazole, such as 5-aminotetrazole, ditetrazolylamine, ditetrazole and salts thereof, nitraminotetrazole and its salts, such as ammonium nitraminotetrazole and aminoguanidinium nitraminotetrazole, aminoguanidine nitrate, 10 diaminoguanidine nitrate, triaminoguanidine nitrate, guanidine nitrate, dicyandiamidine nitrate, diaminoguanidine azotetrazolate.

Thermal pre-ignition agents which, in addition to DPN and the above-mentioned nitrogen-containing compounds, on 15 their own or in mixtures, contain oxidising agents, on their own or in mixtures, in amounts by weight of from 10 to 90 %, such as, for example, nitrates of the alkali or alkaline earth metals or of ammonium, such as sodium nitrate or potassium nitrate, perchlorates of the alkali 20 or alkaline earth metals or of ammonium, peroxides of the alkaline earth metals or of zinc.

Thermal pre-ignition agents which, in addition to DPN, the above-mentioned nitrogen-containing compounds, on their own or in mixtures, and/or the above-mentioned 25 oxidising agents, on their own or in mixtures, contain reducing agents, on their own or in mixtures, in amounts by weight of from 1 to 80 %, such as, for example, aluminium, titanium, titanium hydride, boron, boron hydride, zirconium, zirconium hydride, silicon, graphite, 30 activated carbon, carbon black.

Thermal pre-ignition agents which, in addition to DPN, the above-mentioned nitrogen-containing compounds, on their own or in mixtures, the above-mentioned oxidising agents, on their own or in mixtures, and/or the above- 35 mentioned reducing agents, on their own or in mixtures, contain binders, on their own or in mixtures, in amounts by weight of from 1 to 80 %, such as, for example,

cellulose and derivatives thereof, polyvinylbutyrals, polynitropolyphenylene, polynitrophenyl ether, Plexigum, polyvinyl acetate and copolymers.

5 Thermal pre-ignition agents which, in addition to DPN, the above-mentioned nitrogen-containing compounds, on their own or in mixtures, the above-mentioned oxidising agents, on their own or in mixtures, the above-mentioned reducing agents, on their own or in mixtures, and/or the above-mentioned binders, on their own or in mixtures,
10 contain high-energy additives, on their own or in mixtures, in amounts by weight of from 10 to 80 %, such as, for example, hexogen, octogen and nitrocellulose.

Thermal pre-ignition agents which, in addition to DPN, the above-mentioned nitrogen-containing compounds, on
15 their own or in mixtures, the above-mentioned oxidising agents, on their own or in mixtures, the above-mentioned reducing agents, on their own or in mixtures, the above-mentioned binders, on their own or in mixtures, and/or the above-mentioned high-energy additives, on their own
20 or in mixtures, contain combustion moderators and processing aids, on their own or in mixtures, in amounts by weight of from 0.1 to 20 %, such as, for example, ferrocene and derivatives, acetonylacetates, salicylates, silicates, silica gels, boron nitride.